

Climate Quality Ocean Color Time Series: Vicarious Calibration Requirements - MOBY

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Office of Research and Applications
with

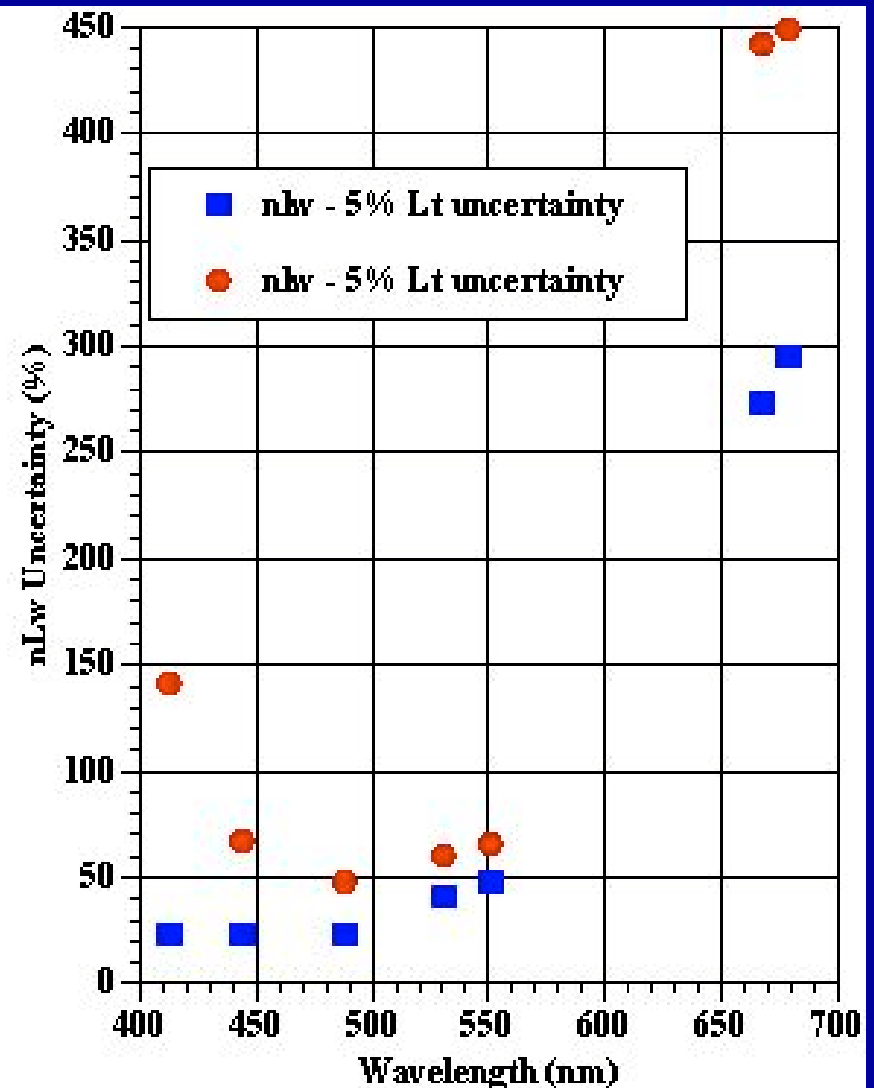
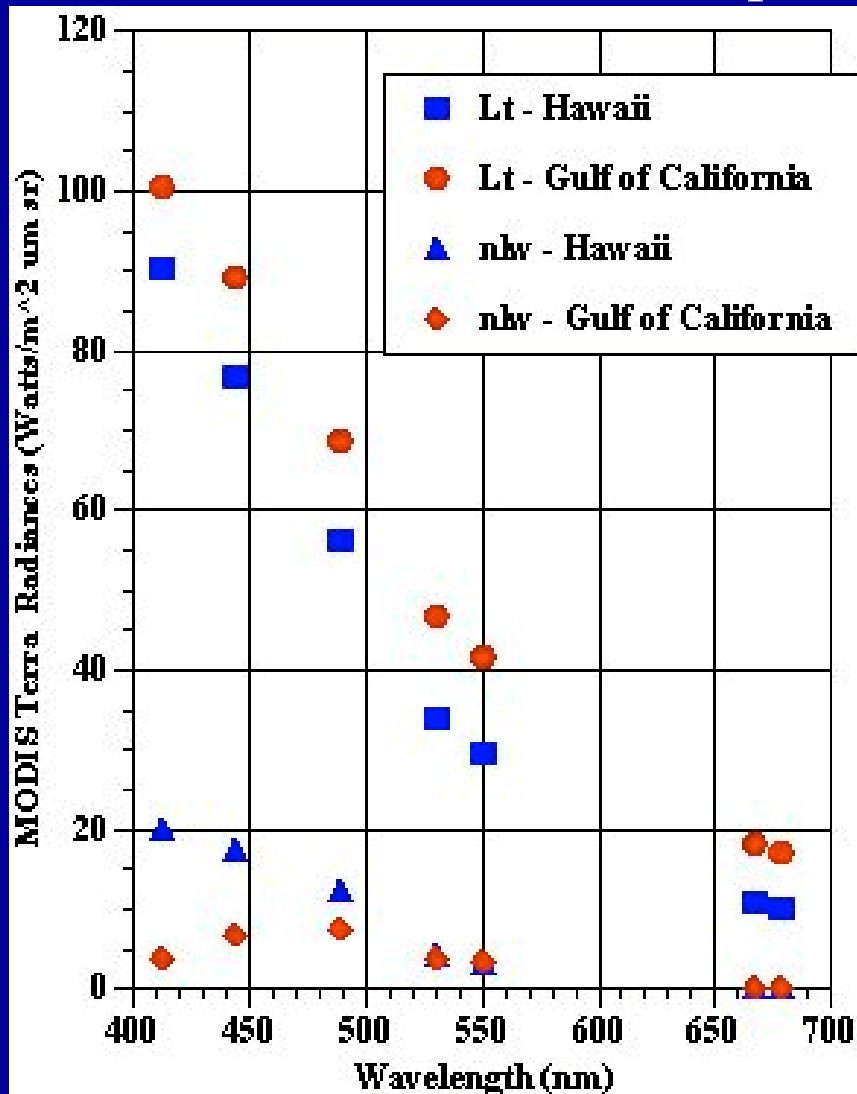
MOCE/MOBY Team Members

Ocean Color Forum 14 April 2004

Water-leaving Radiance Retrieval Uncertainty

SeaWiFS - NIST Calibration 4% MODIS ; 5%

Assume Atmospheric Correction is Perfect



Vicarious Calibration Required for Ocean Color Science

**Atmospheric Correction is an Inherent Part of the
Calibration Process.**

**Laboratory and On-board Sensor Calibrations Cannot
Meet the Accuracy Requirements for this Science
Application.**

**A Minimum of an Order of Magnitude Improvement in
Radiometric Calibration Accuracy is Required.**

Vicarious Calibration Site Criteria

Oligotrophic Waters -Stable Target

Low Horizontal Gradients

Optically Deep

High Signal In Blue

Maritime Atmosphere

Small Aerosol Component

Avoid Absorbing Aerosol

Characterize

Physical, Biological, & Optical

BDRF Measurements & Models

Serviceability

Convenient Logistic Support

Safety - Diver & small boat operations

Vicarious Calibration Optical System Criteria

Optical

High Spectral Resolution (1-2 nm)

Large spectral range (350 - 900 nm)

High stray light rejection

Temperature Stabilization

Reference lamps for stability monitoring

Calibration

NIST traceability & overview

Wavelength calibrations - low pressure lamps and lasers

Characterization

Stray light

Thermal

Linearity

Vicarious Calibration Buoy System Criteria

Buoy

Stable - small tilt angles

Minimized shadowing effects

Data & system status telemetry

Characterization

Shadowing Correction Models

Reliability

Minimize structural degradation for deployment periods of four months.

Minimize bio-fouling and provide for systematic cleaning and *in situ* reference calibrations.

Initial Proposal for MODIS Vicarious Calibration

Based on DOE Ozone Monitoring Program:

A few primary sites instrumented with high-end optical systems (Fastie -eight meter double spectrometers).

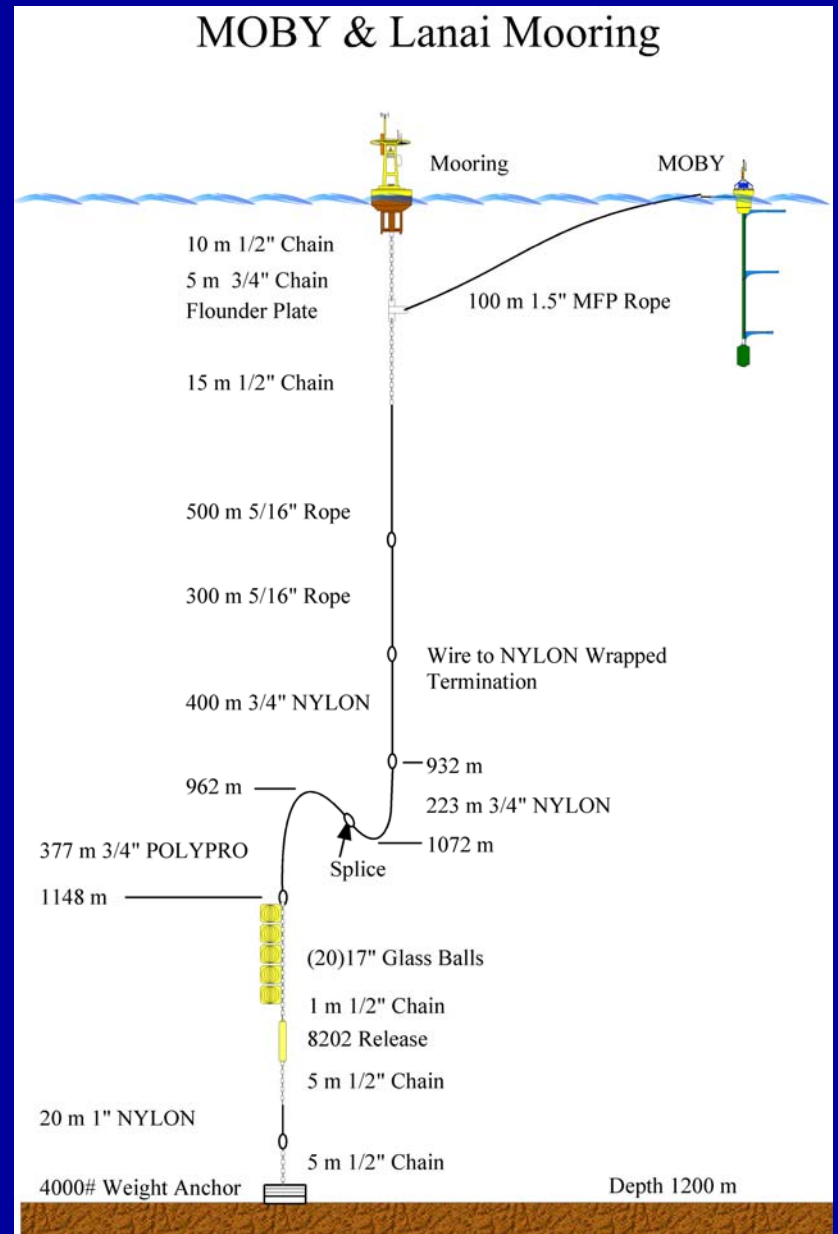
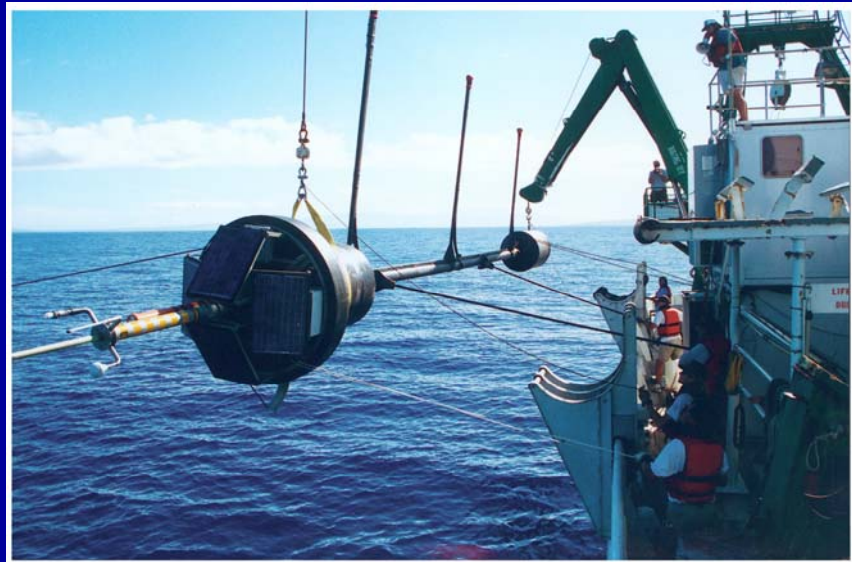
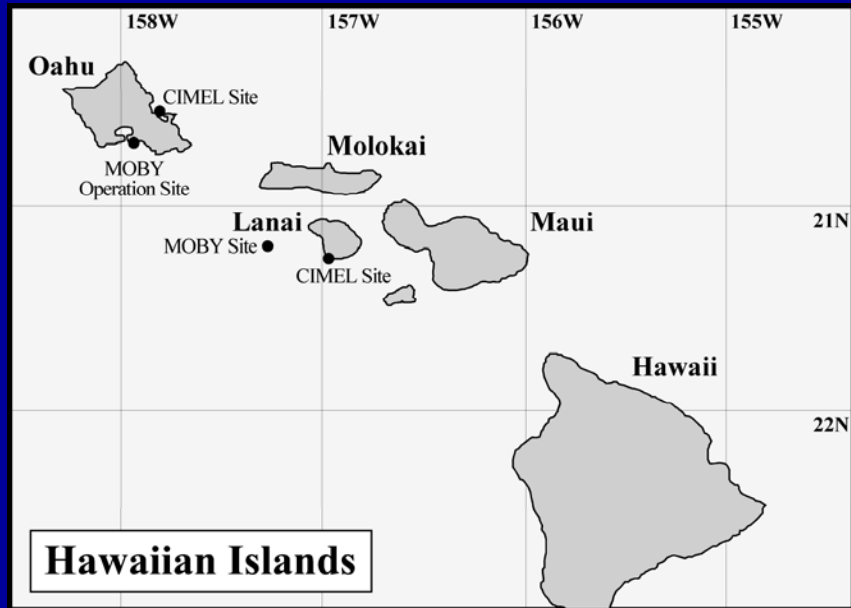
High density geographic coverage with Dobson meters.

MODIS Proposal:

MOBY's at five sites - Hawaii, Bermuda, Mediterranean , Brazil, and Australia.

Optical Drifters and at-sea bio-optical campaigns

MOBY Mooring Site



MOBY Operations Site - Univ. Hawaii



Pier Side - 30,000 sq. ft

16 Portable vans/tent

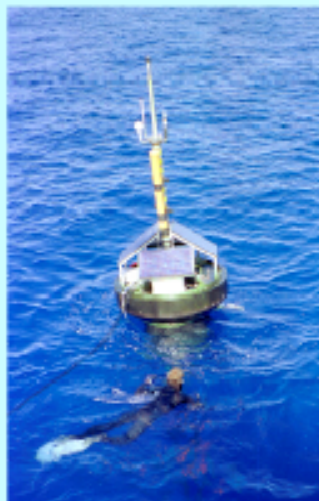
offices, shops, storage, labs (calibration, optics assembly, filtration)

6 Shipboard Vans

3 labs - (wet, optics, data acquisition) power, storage, & office

Pier side Support - cranes, machine shop.

The diagram illustrates the ROV system components and their connections. At the top, a yellow ROV is shown with a central vertical shaft. A cable labeled 'Cables to upper mast' connects the ROV to the upper mast. A 'Removable Protection Devices' is located on the side of the ROV. A 'Spar Assembly' is shown in the center, with a cable labeled 'Cables to Lower Mast' connecting it to the lower mast. A 'Teether' is shown on the side of the spar assembly. A 'Stainless Steel Frame' is shown at the bottom of the spar assembly. The entire system is supported by a 'MOBY Controller' at the top.

[illegible]

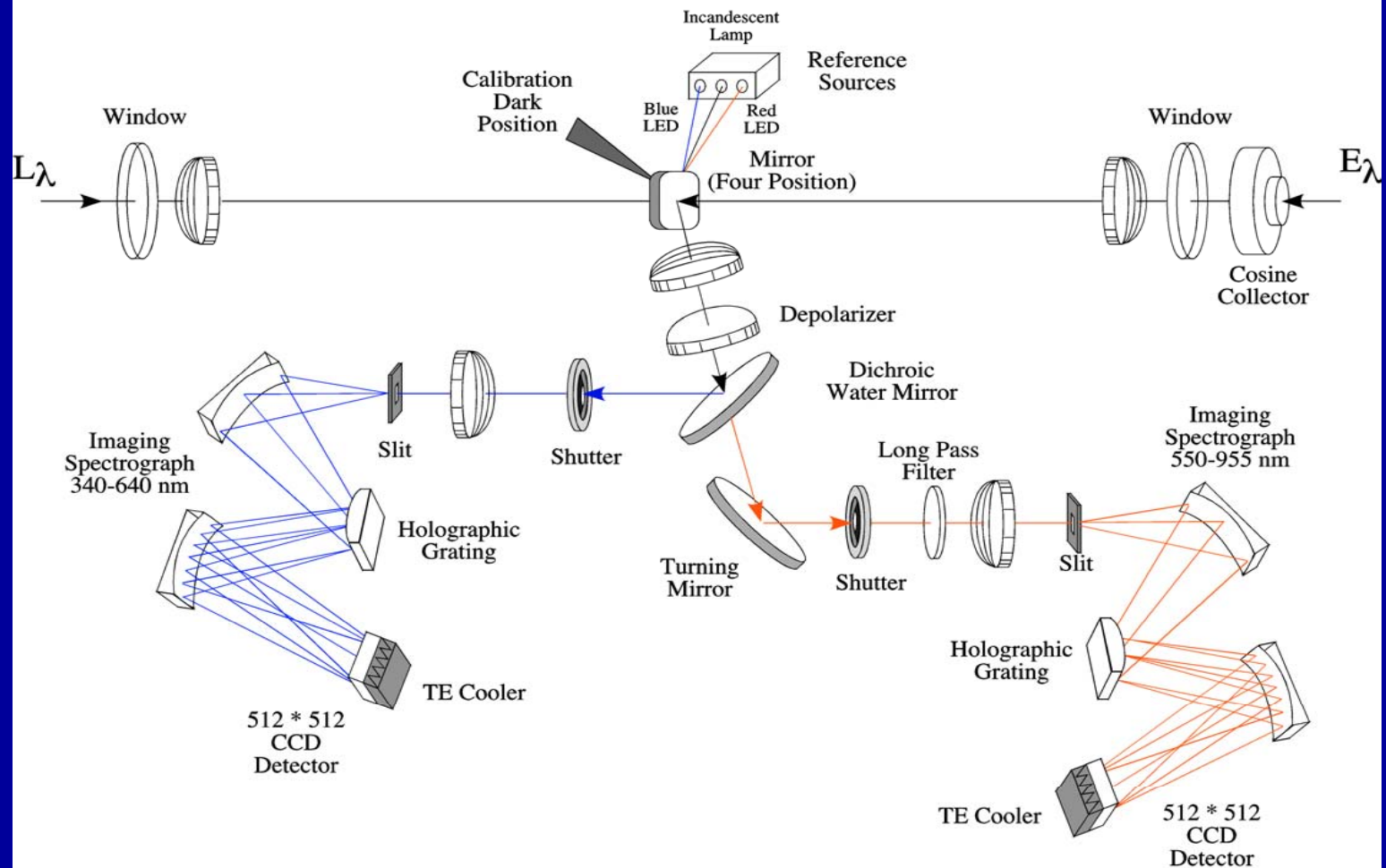
The diagram illustrates the vertical profile of the instrumented mooring system. Key components and depths are labeled as follows:

- Surface Components:**
 - Es Collector
 - GPS, RDF, ARGOS, Cellular, Strobe
 - Solar Panels 4 x 40 W
 - MOBY Surface Float:
 - * TT7 Control Unit
 - * Cellular Transceiver
- Depth 1 m:** The yellow surface float is shown at this depth. A horizontal dimension of 3 m is indicated for the float's width.
- Depth 5 m:** A horizontal arm extends from the mast at this depth, carrying:
 - Ed Collector
 - Lu Collector
 The horizontal distance from the mast to the collectors is 2.5 m.
- Depth 9 m:** A horizontal arm extends from the mast at this depth, carrying a Collector Standoff. The horizontal distance from the mast to the standoff is 2 m.
- Depth 12 m:** The bottom of the instrument bay is located at this depth. The instrument bay contains:
 - * MOS System
 - * Power Junction
 - * Batteries
- Other Labels:**
 - Mooring Tether
 - Fiber Optic Cable Pass
 - Fiberglass Mast

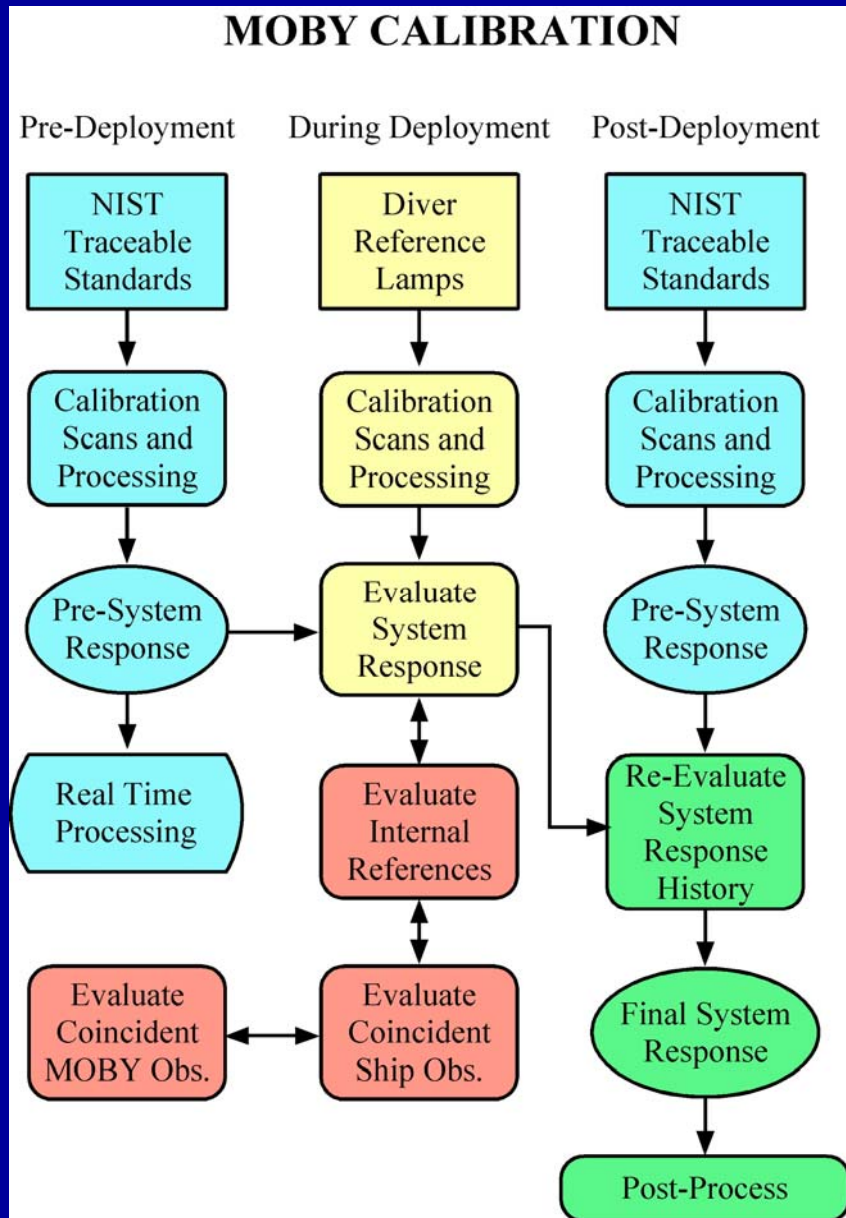


MOBY Optical System

Marine Optical System - Dual Spectrographs



MOBY Calibration Process



NIST Collaborations

Training

NIST Primary Lamb Standards

Annual On Site Calibration Systems Check

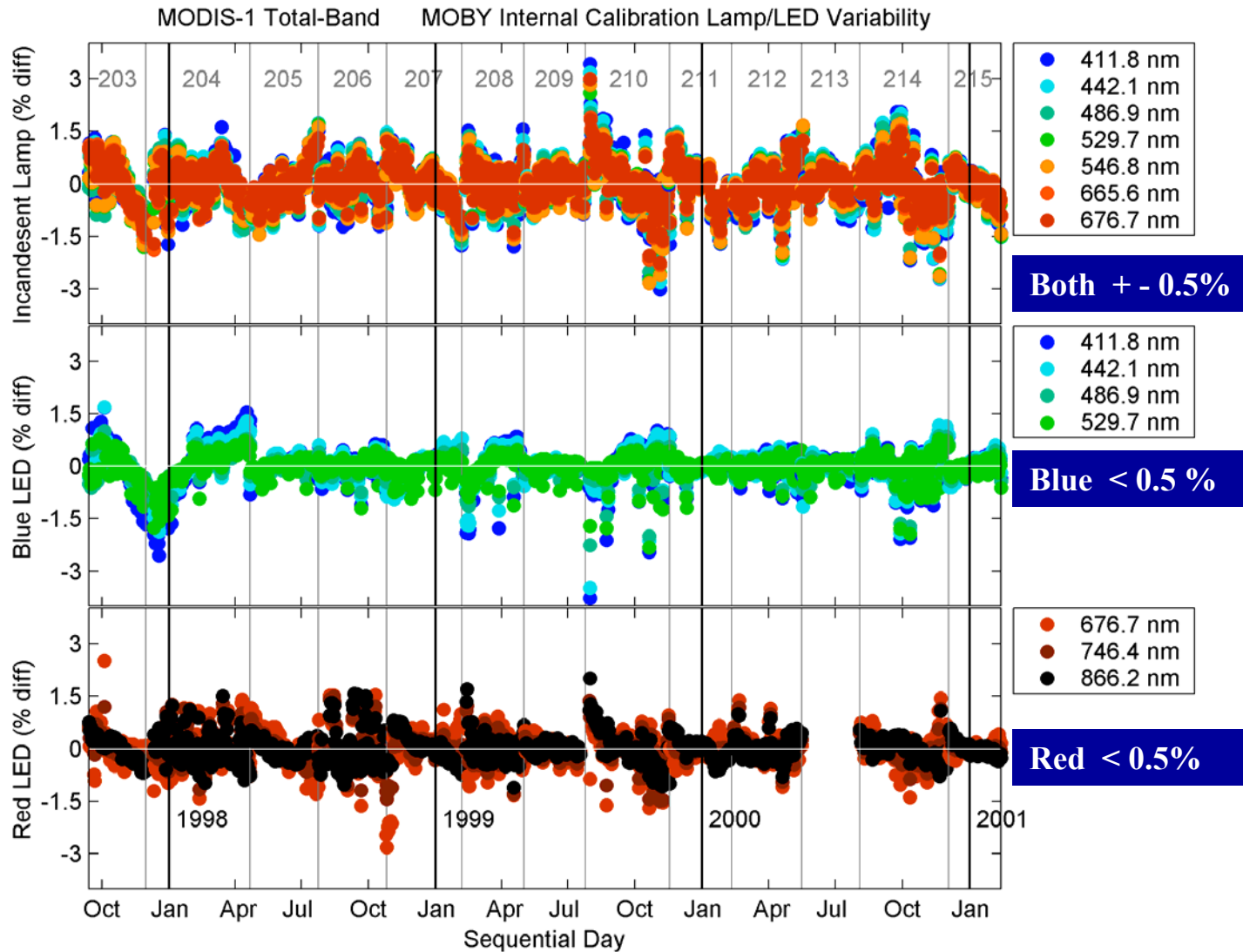
Pre/Post Cal. System monitoring with NIST Cal. Radiometers

SIRCUS - Stray Light Characterizations on MOBY and Shipboard Spectrometers

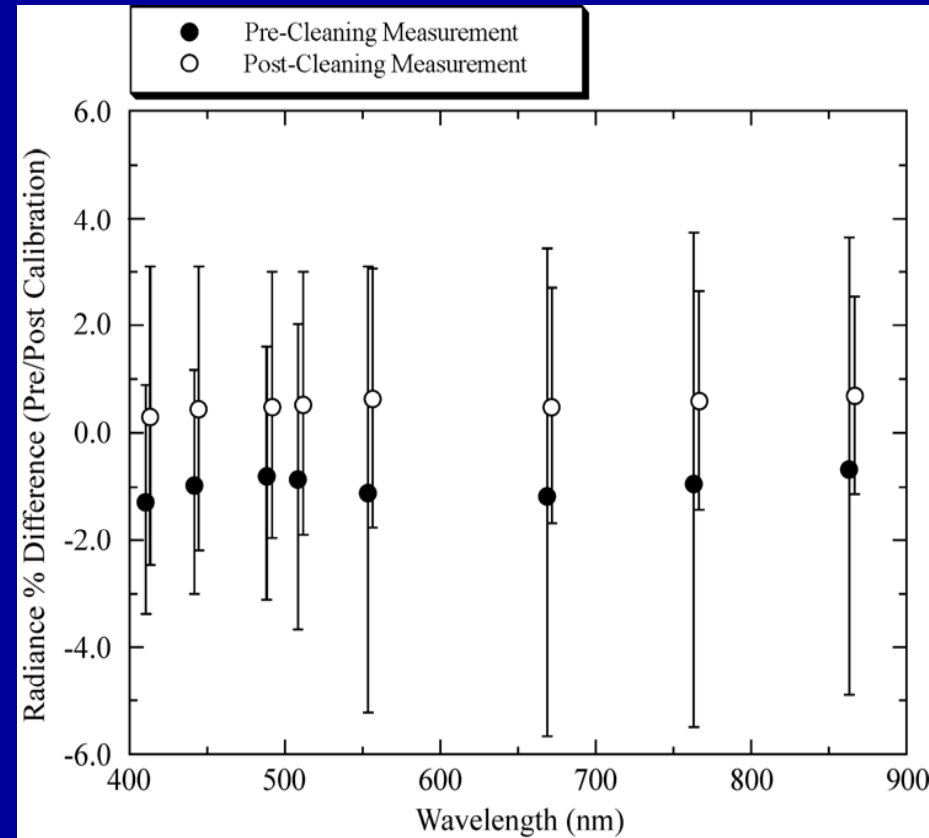
MOCE Calibration Systems (OL420 & OL425) now Calibrated at NIST

Initiating the development of new LED Radiometric Calibration Sources for Oceans

Internal Reference Lamps - Stability QC

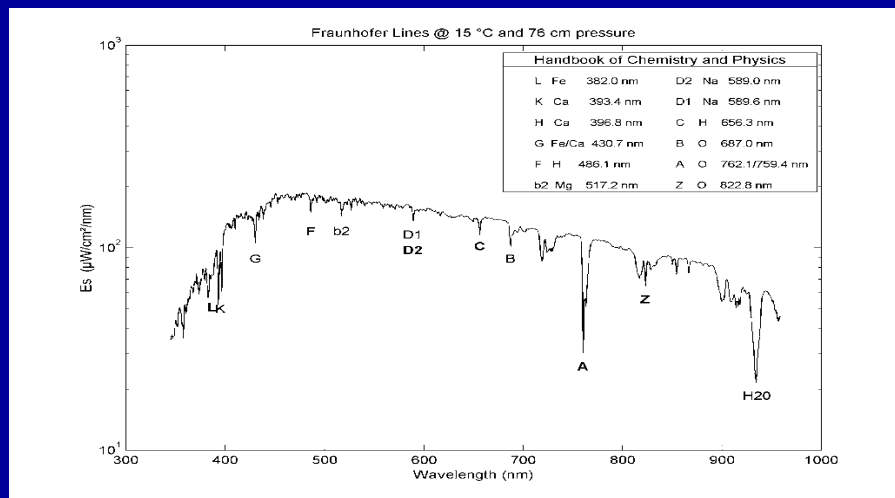


Diver Reference Lamp - Pre/Post Cleaning QC

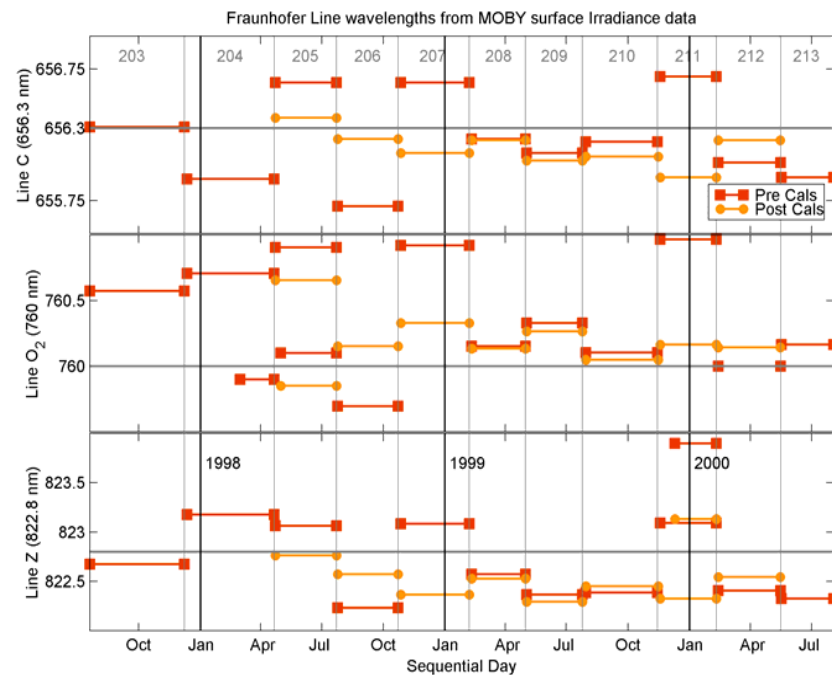
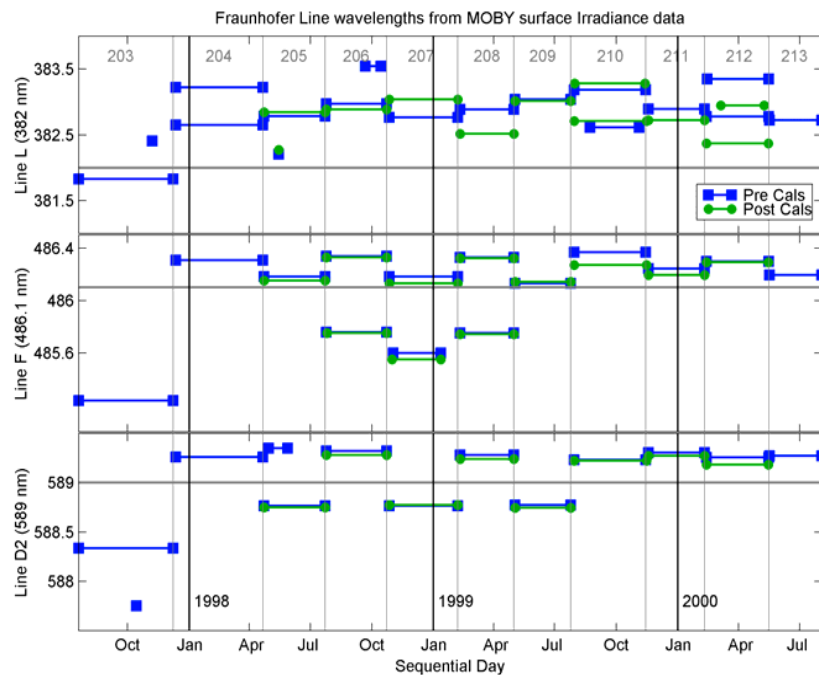


Spectral Calibration QC-Solar

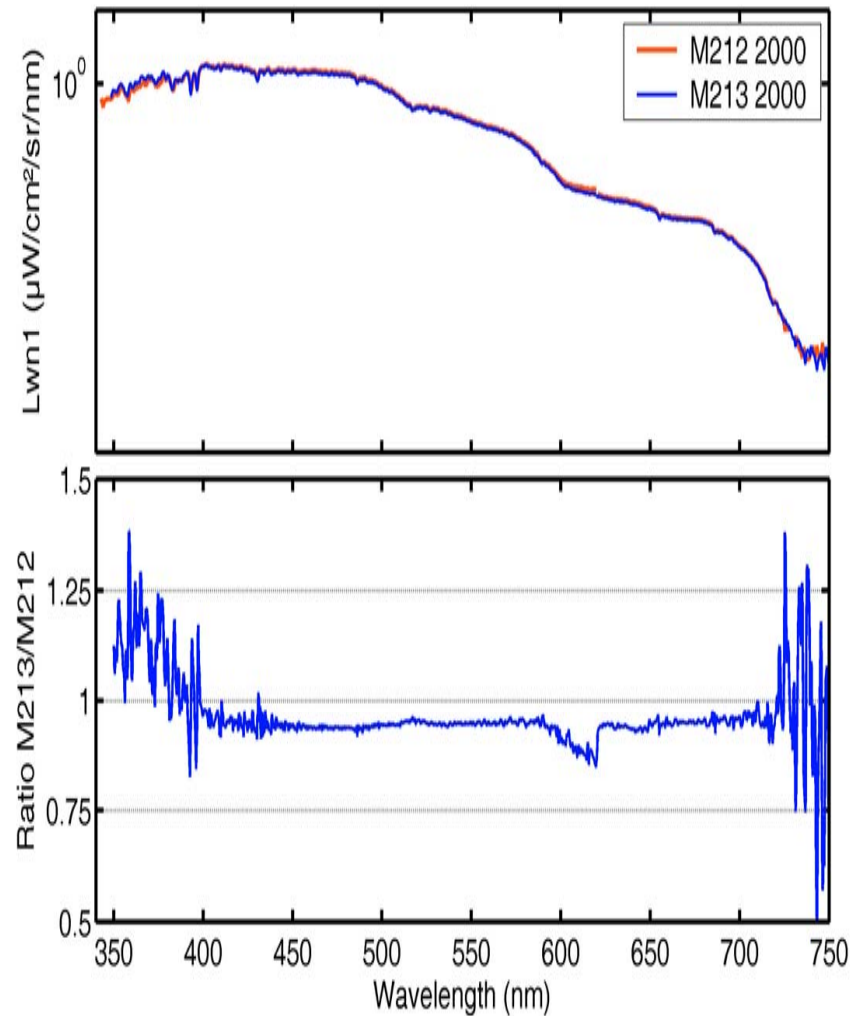
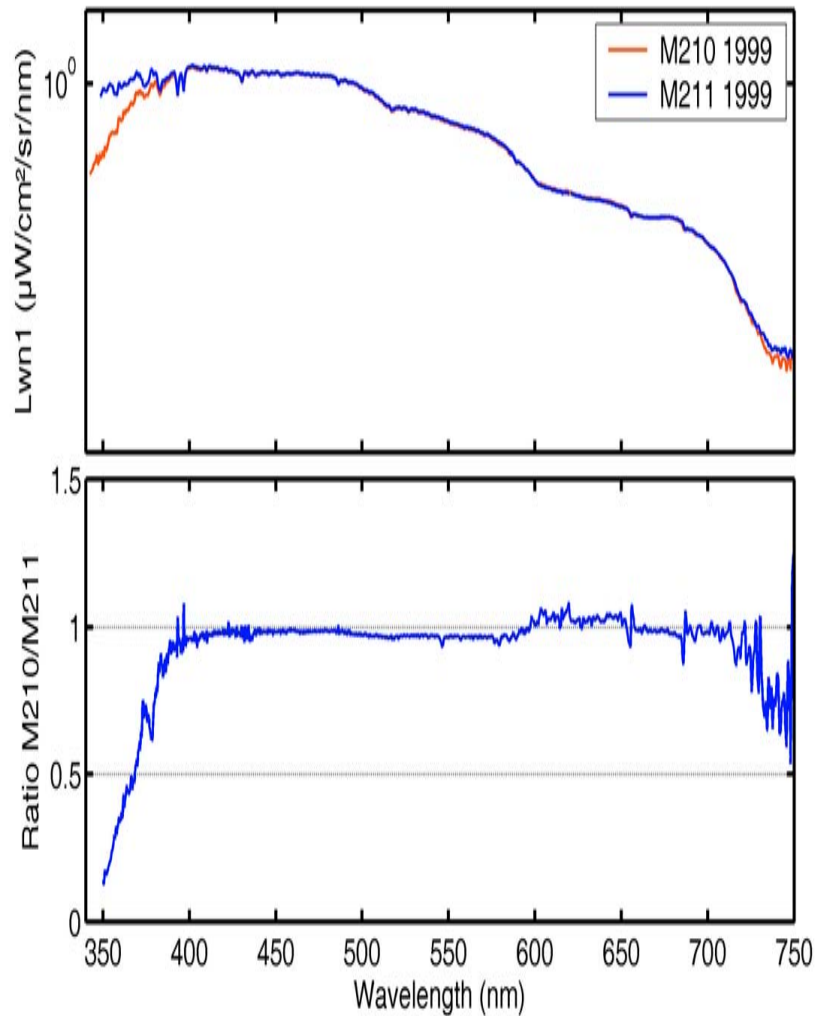
Blue Spectrograph
2.5 years
Approx. $\pm 0.6\text{nm}$



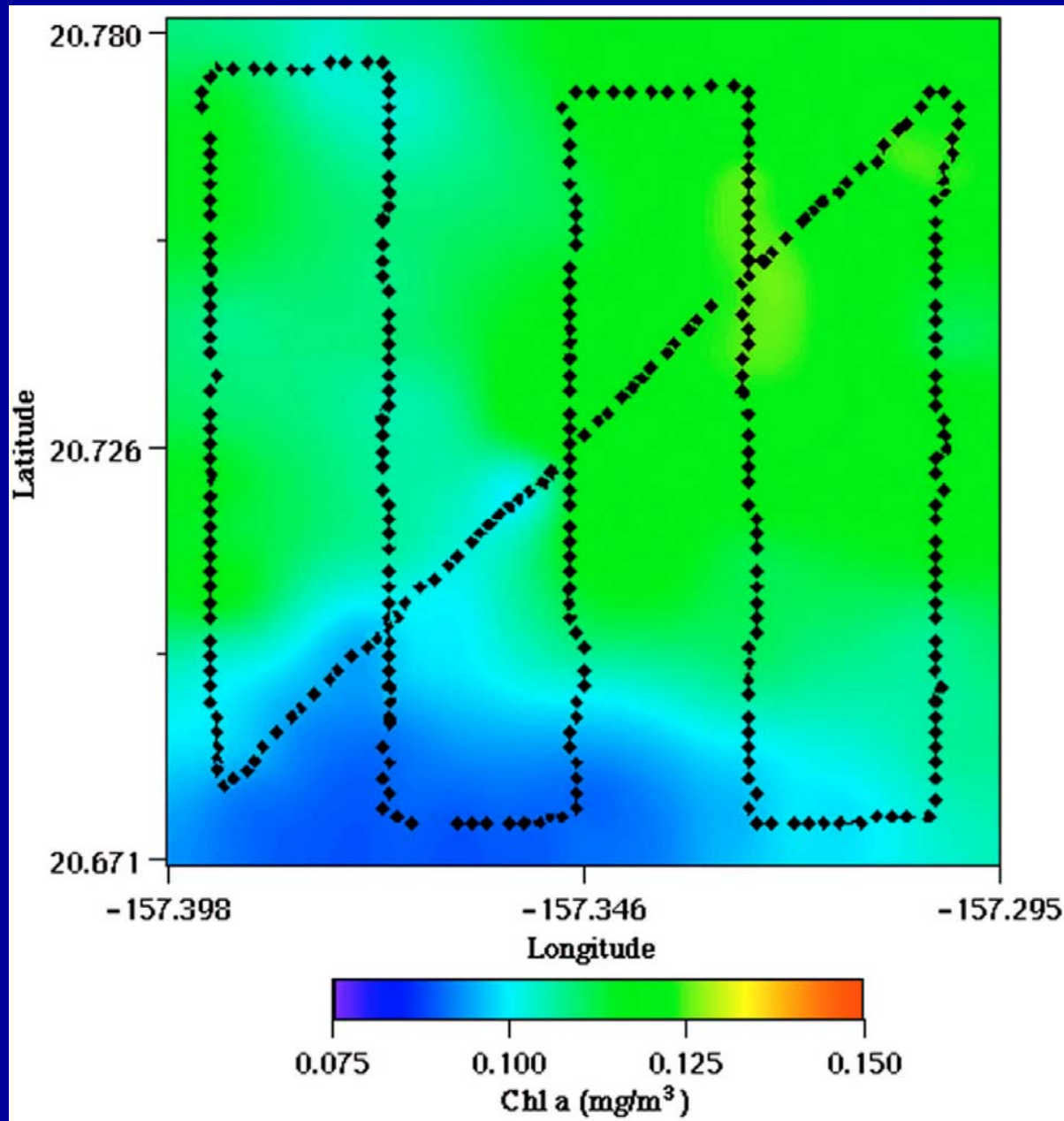
Red Spectrograph
2.5 years
Approx. $\pm 1\text{nm}$



MOBY Crossover Comparisons



Horizontal Chlorophyll-a Variability Survey

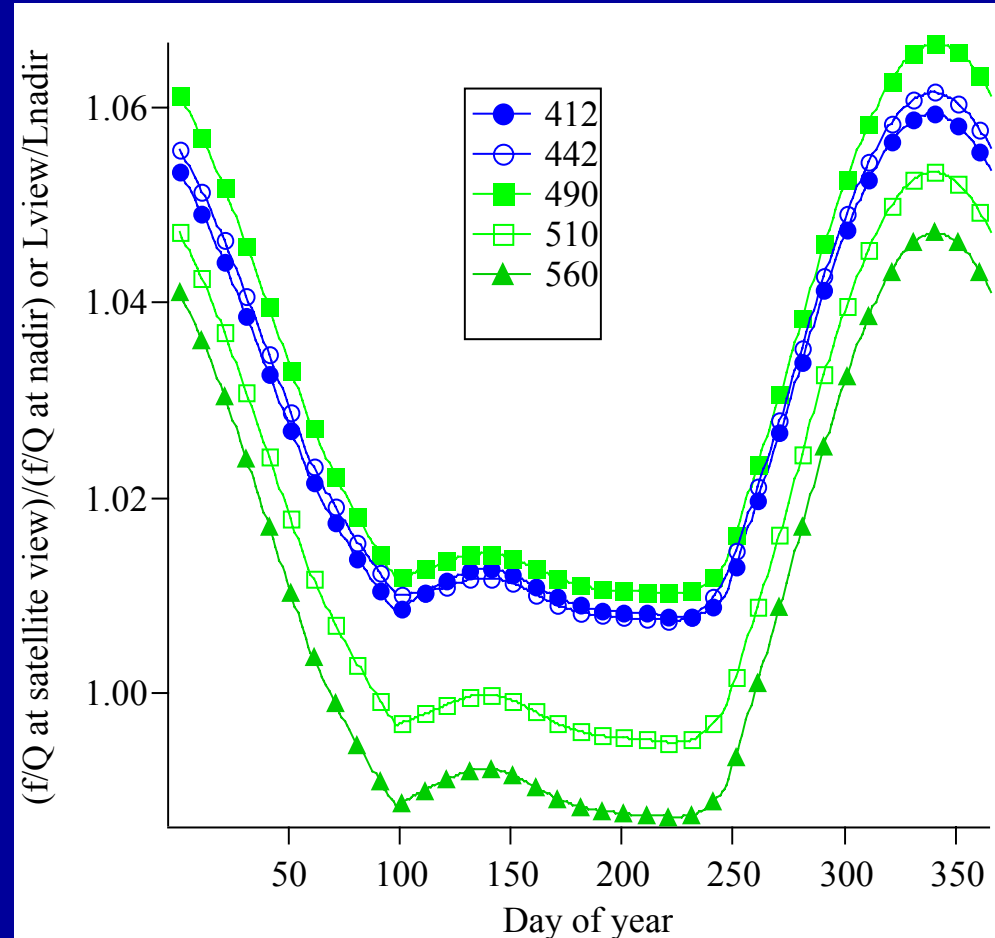


Grid Size:
12x12 Km

Min: 0.089
Max: 0.126
Mean: 0.110
Delta: 0.038

MOBY BDRF Measurements (Ken Voss)

- MODIS views MOBY from 14 specific geometries.
- Sun-MODIS geometry varies in a regular manner throughout the year
- Use NuRADs data to empirically model this variation

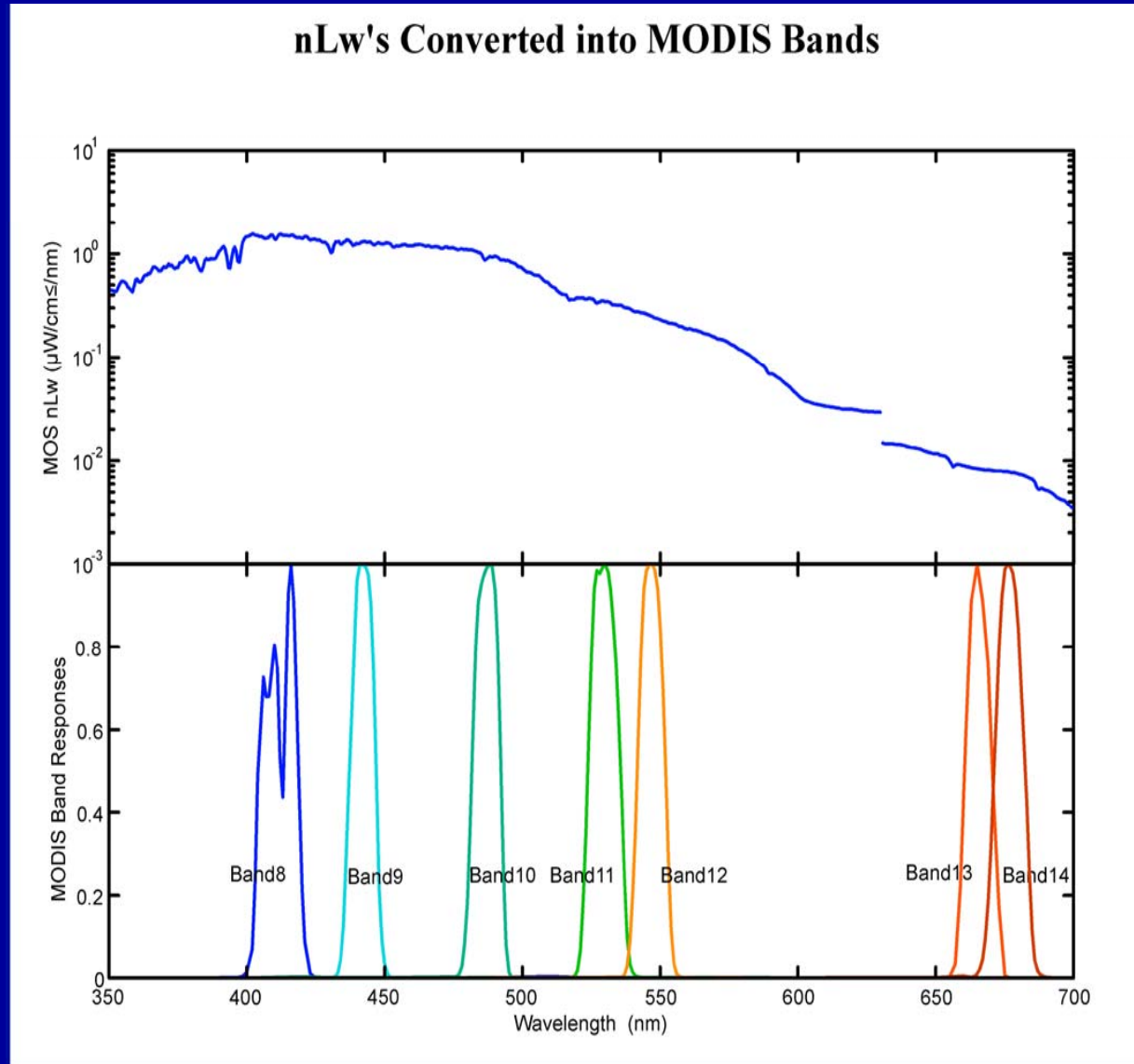


Example for measurement at 22:04 UT.,
Satellite view is 53 degrees.

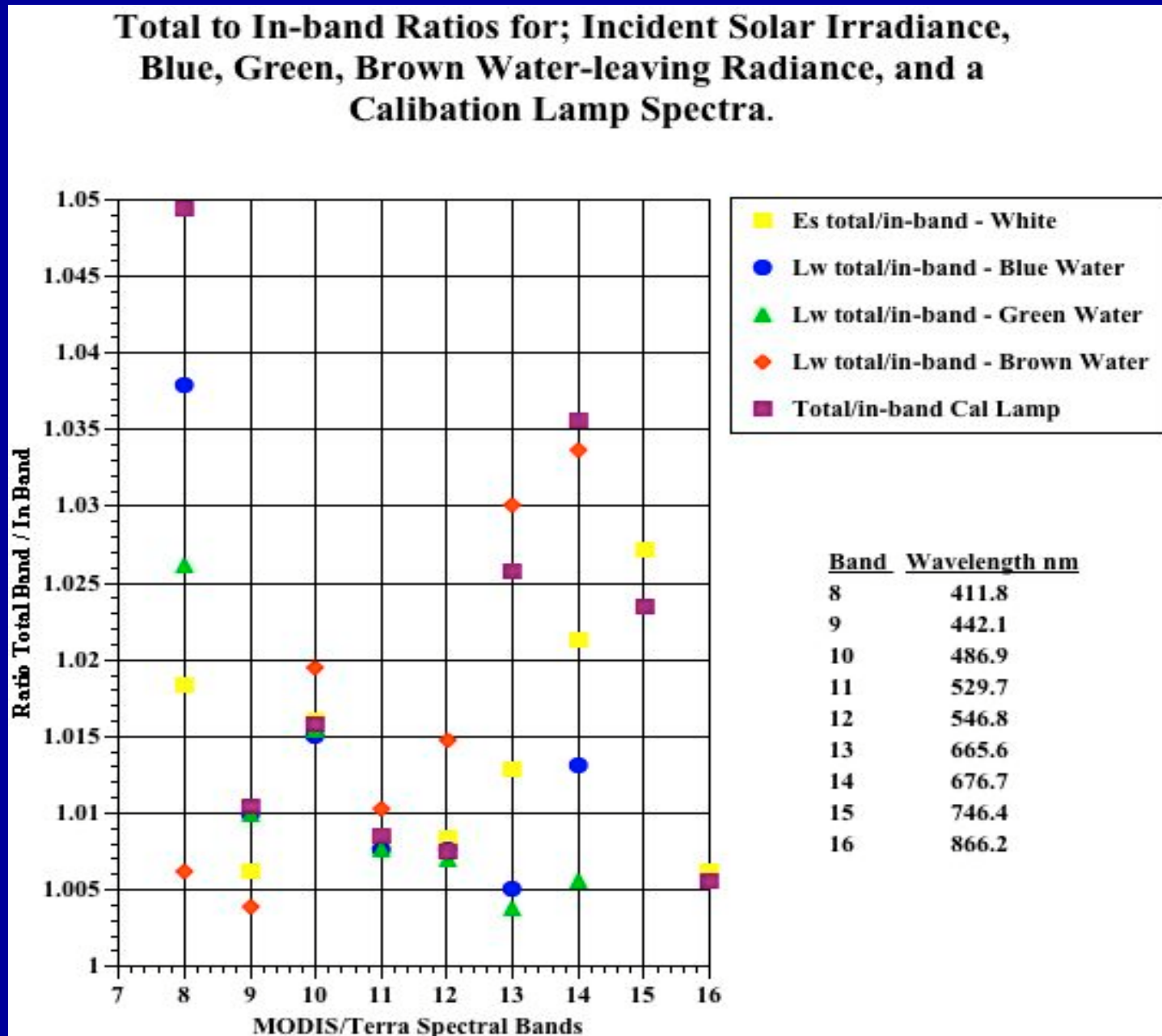
Spectral Band Considerations

Spectral Band Pass Matching

High Resolution Spectra Convolved to Sensor's Spectral Band Pass

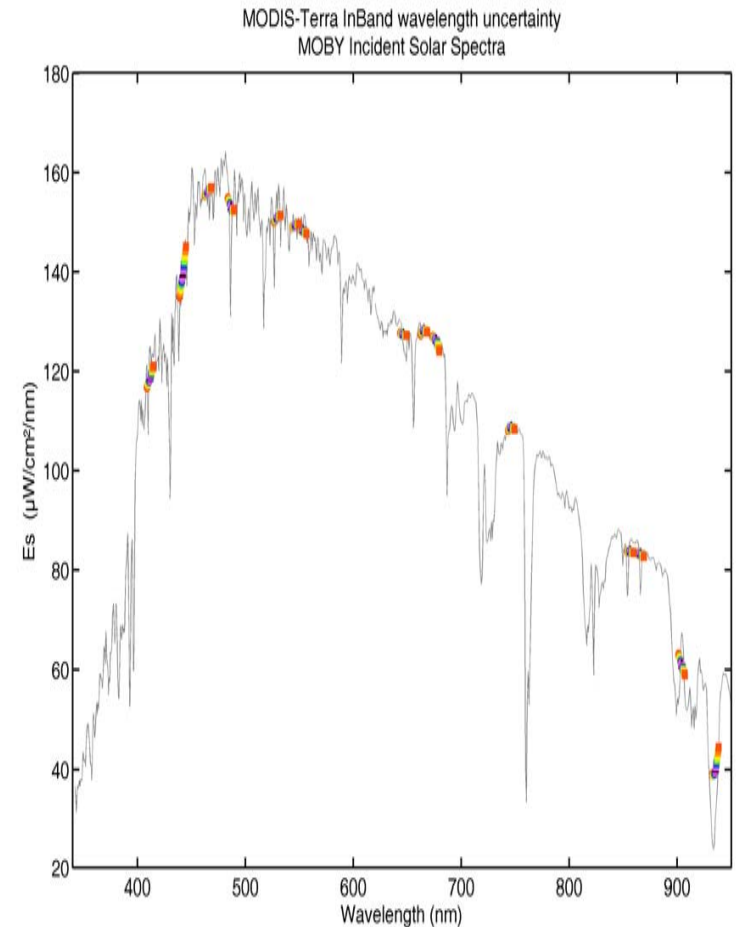
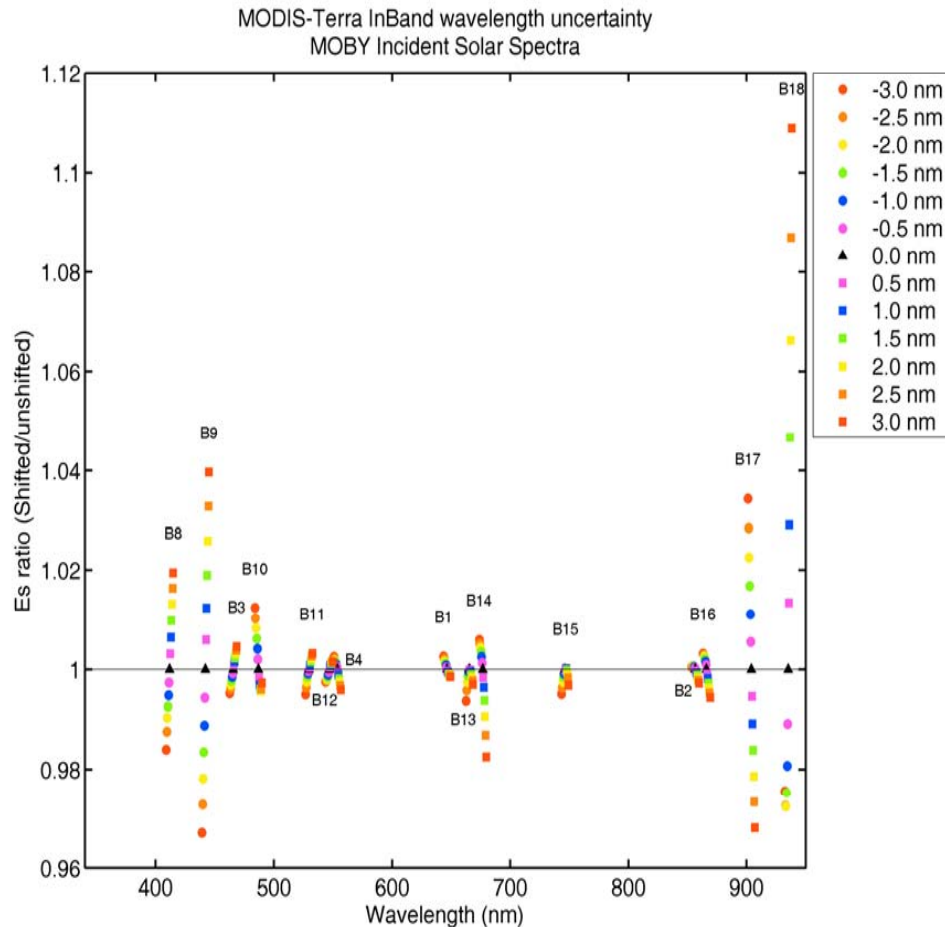


Spectral Band Uncertainties-MODIS Terra



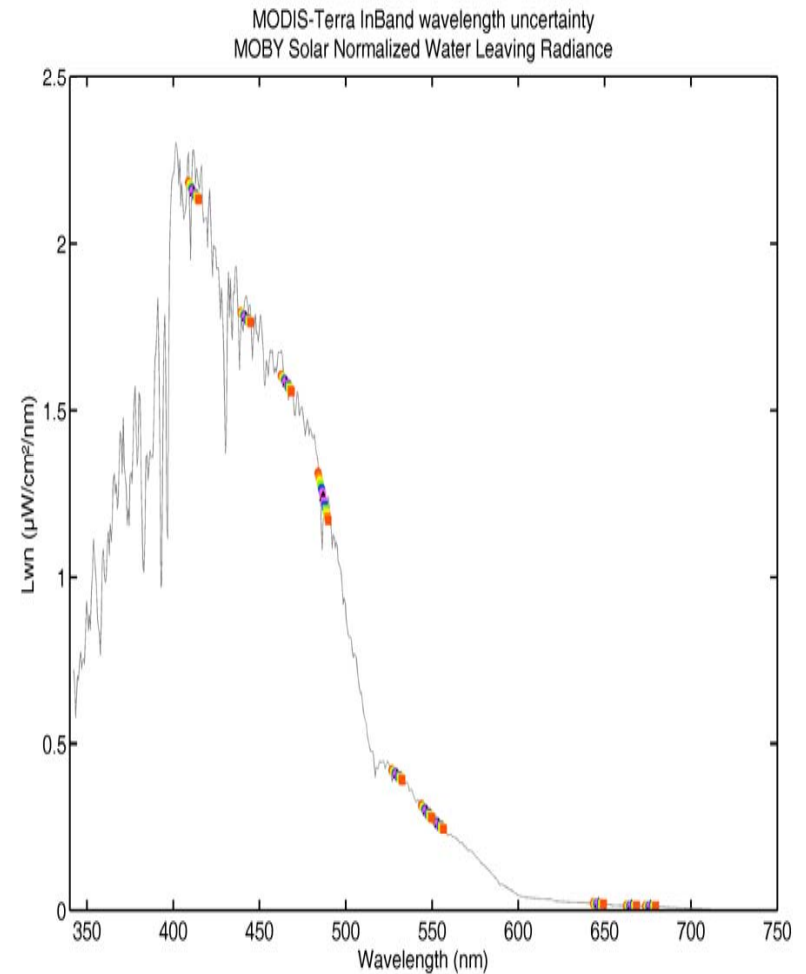
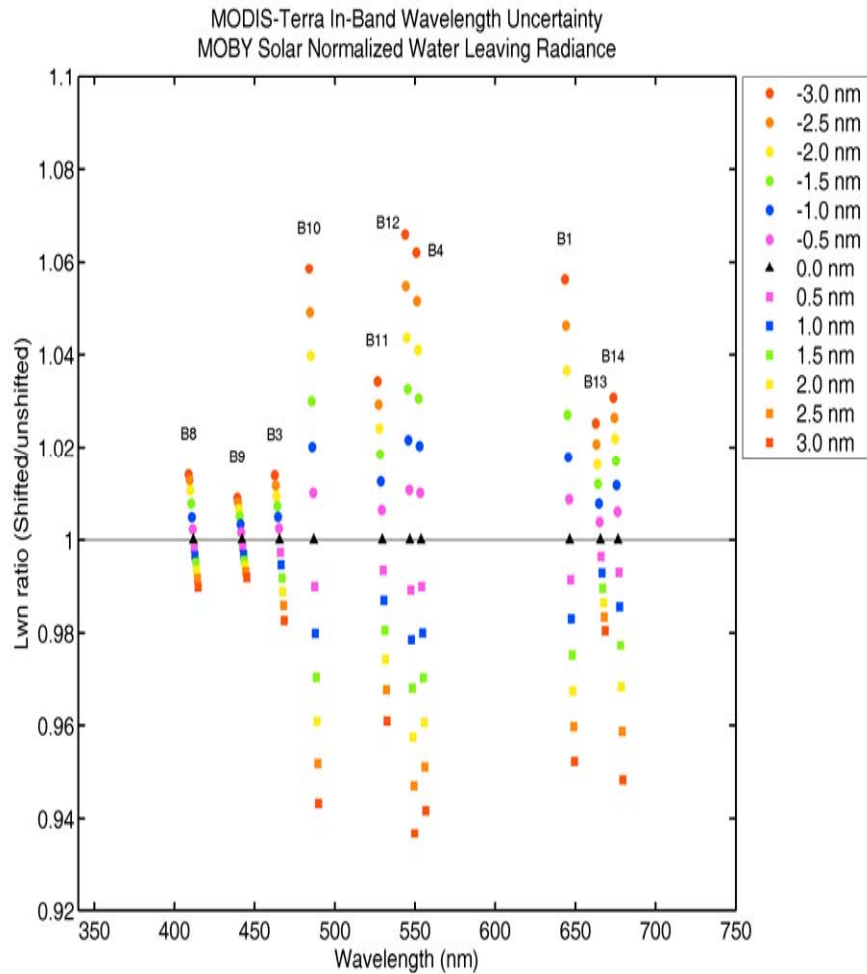
Spectral Band Systematic Uncertainties

Wavelength Shifts - Es - 0.05nm steps

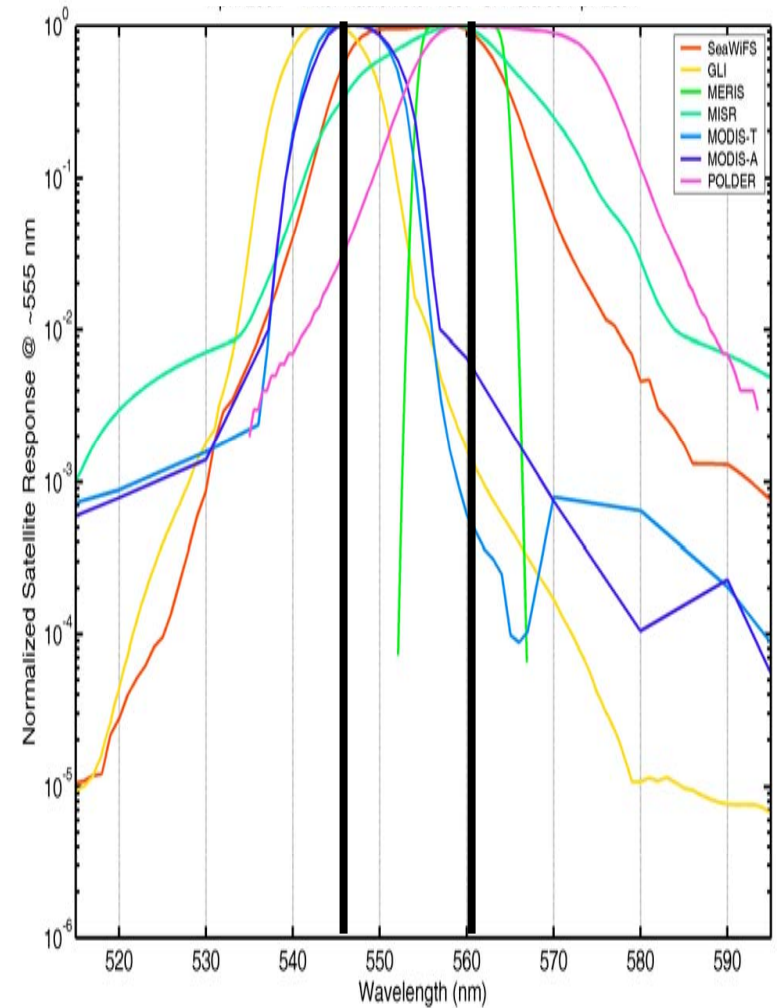
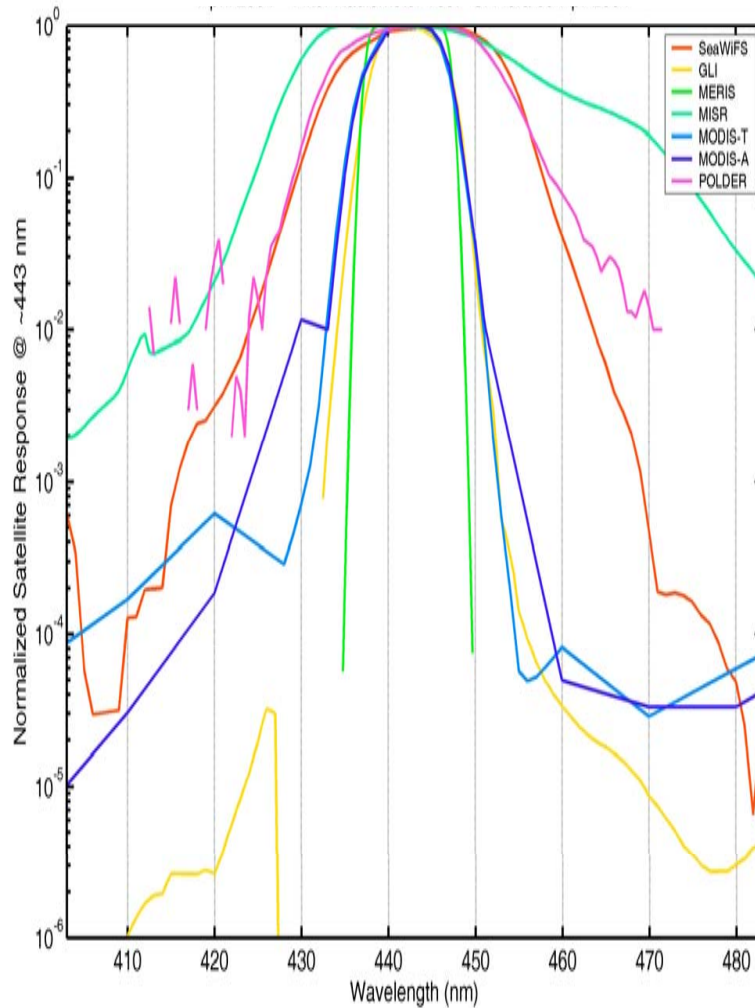


Spectral Band Systematic Uncertainties

Wavelength Shifts - Lwn - 0.05nm steps

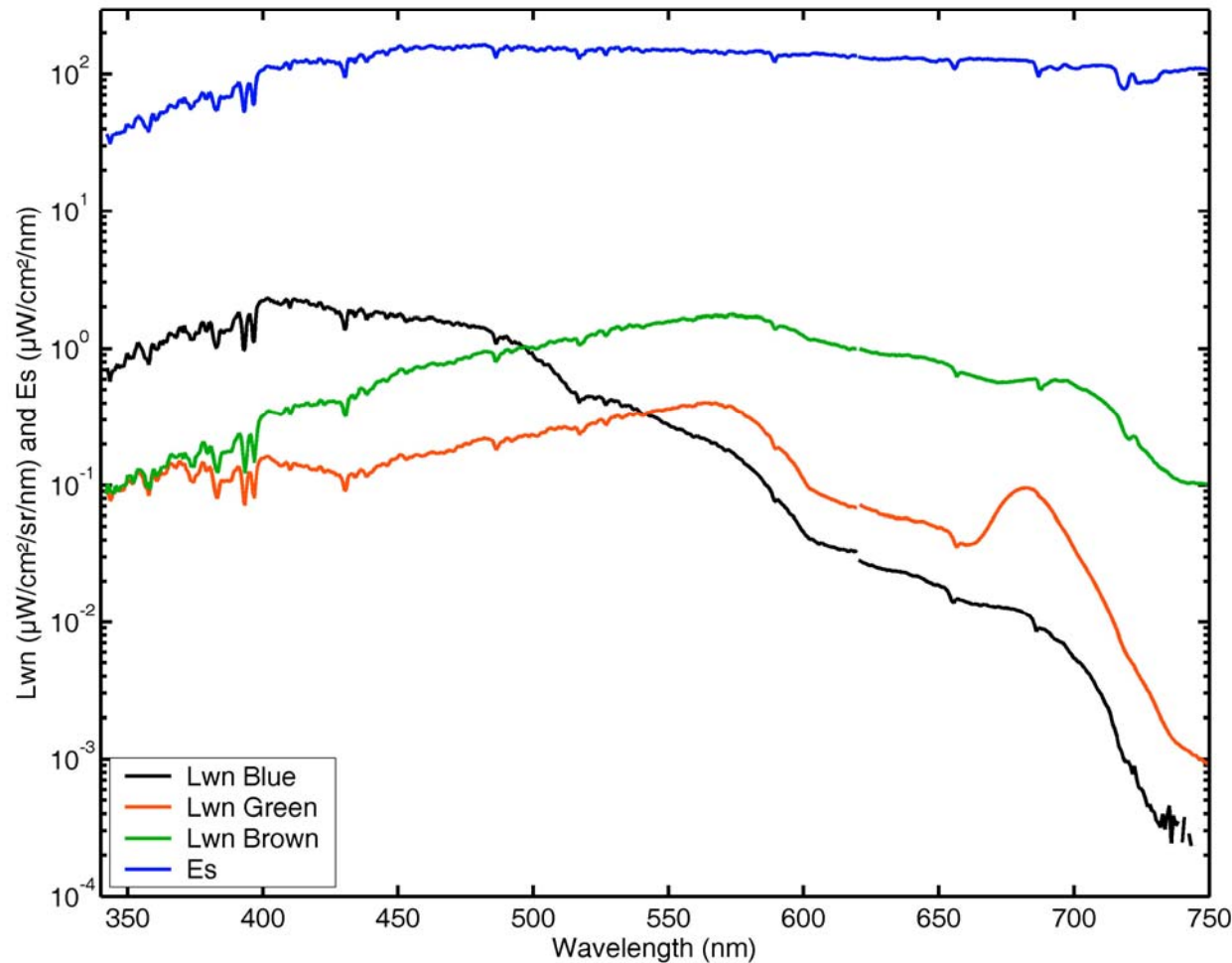


Spectral Band Passes - OC Missions



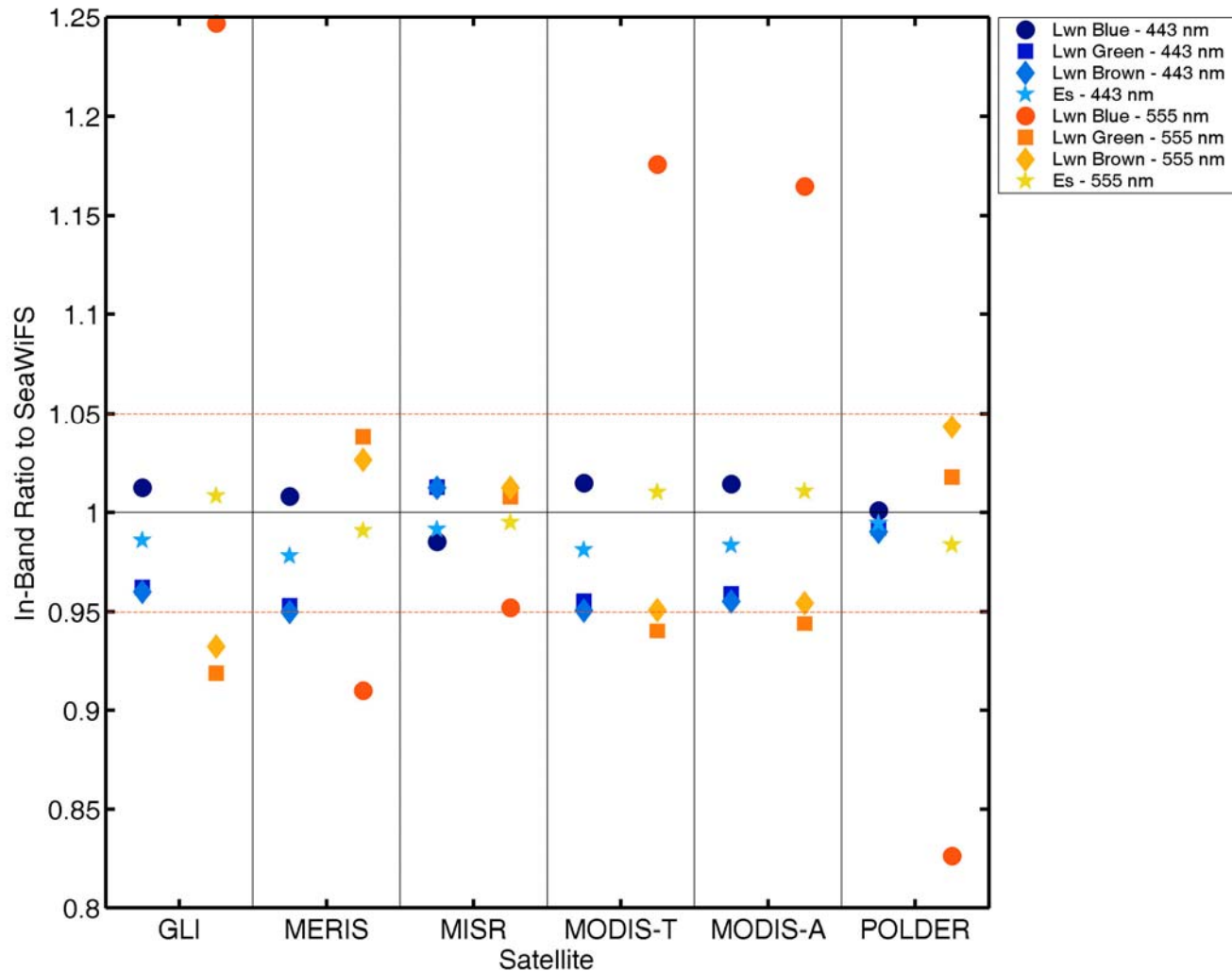
Spectral Band Pass Matching

High Resolution Spectra Convolved to Sensor's Spectral Band Pass



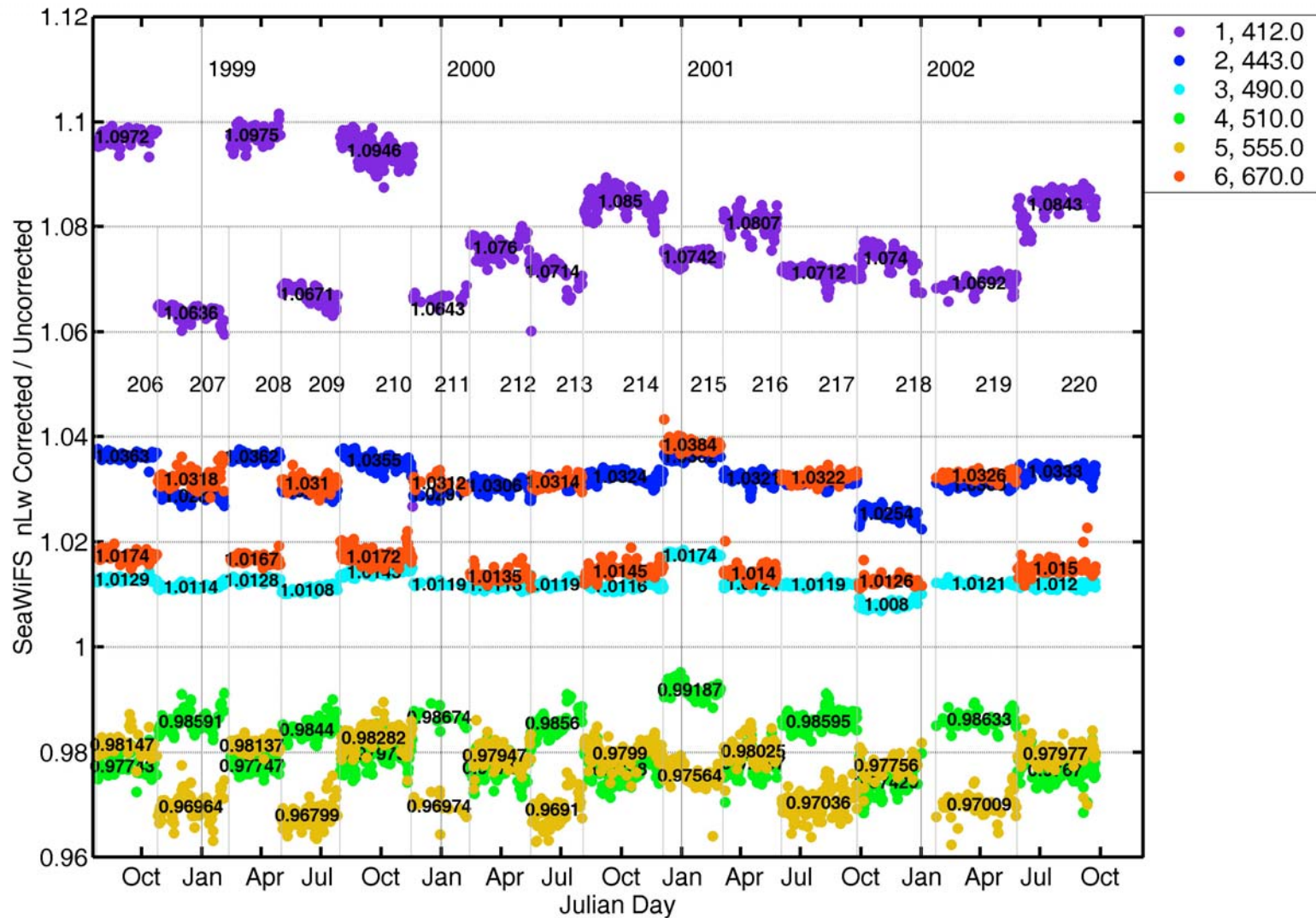
Spectral Band Systematic Uncertainties

SeaWiFS In-Band Response Ratios to Other OC Sensors



Reduction of Systematic Uncertainties - MOBY

SeaWiFS Stray Light Time Series Corrections



Major MOBY Reprocessing Elements

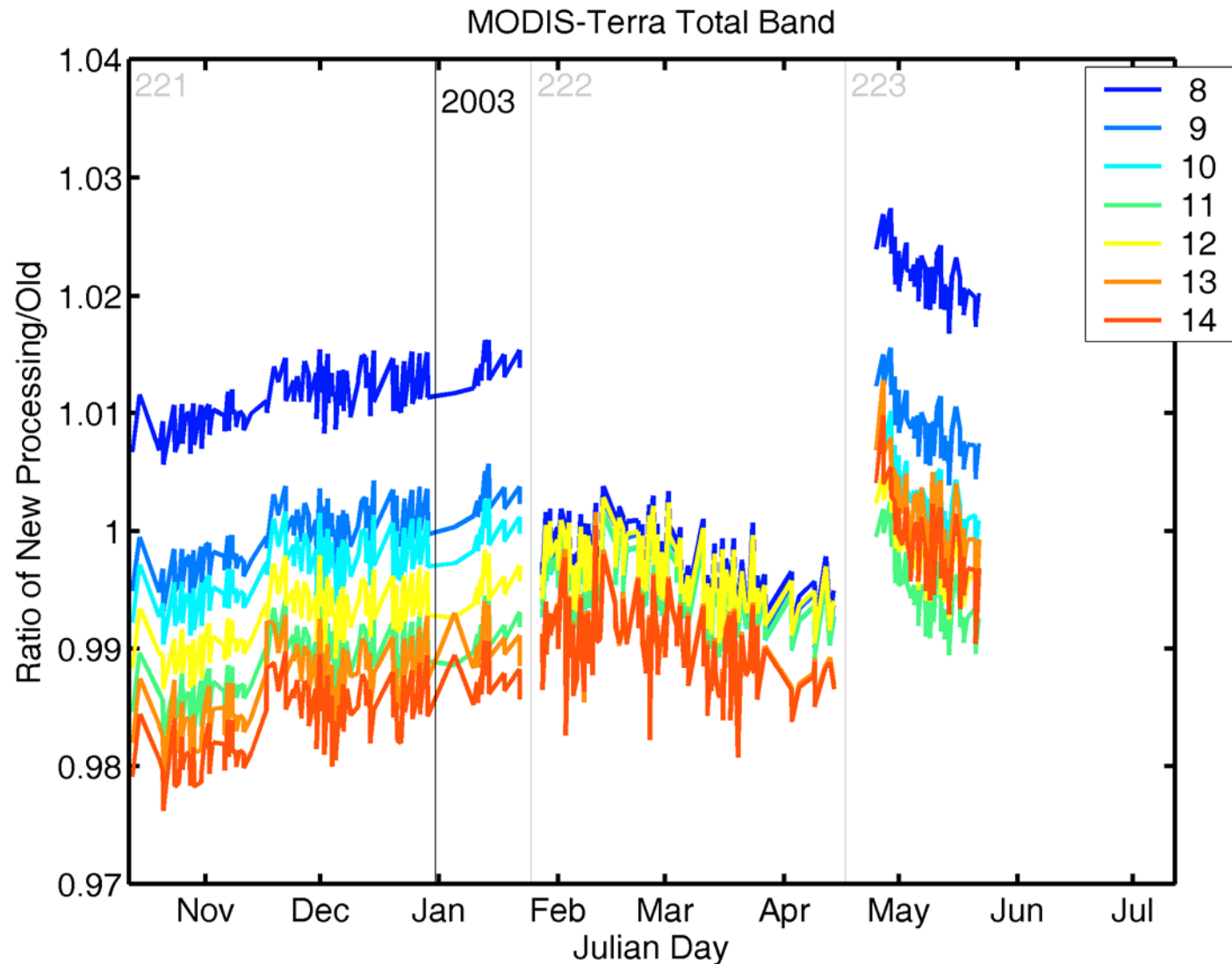
Thermal Corrections - A correction for temperature of approximately 0.5% per degree is being applied to system responses and *insitu* data.

Stray-light Model Version 2 - Implemented an improved characterization of the MOS spectrographs to develop a more detailed model of the instrument slit scatter function. This resulted in a more accurate measure of scattered light in the system and impacted the measured Lu's - primarily at the ends of each spectrograph.

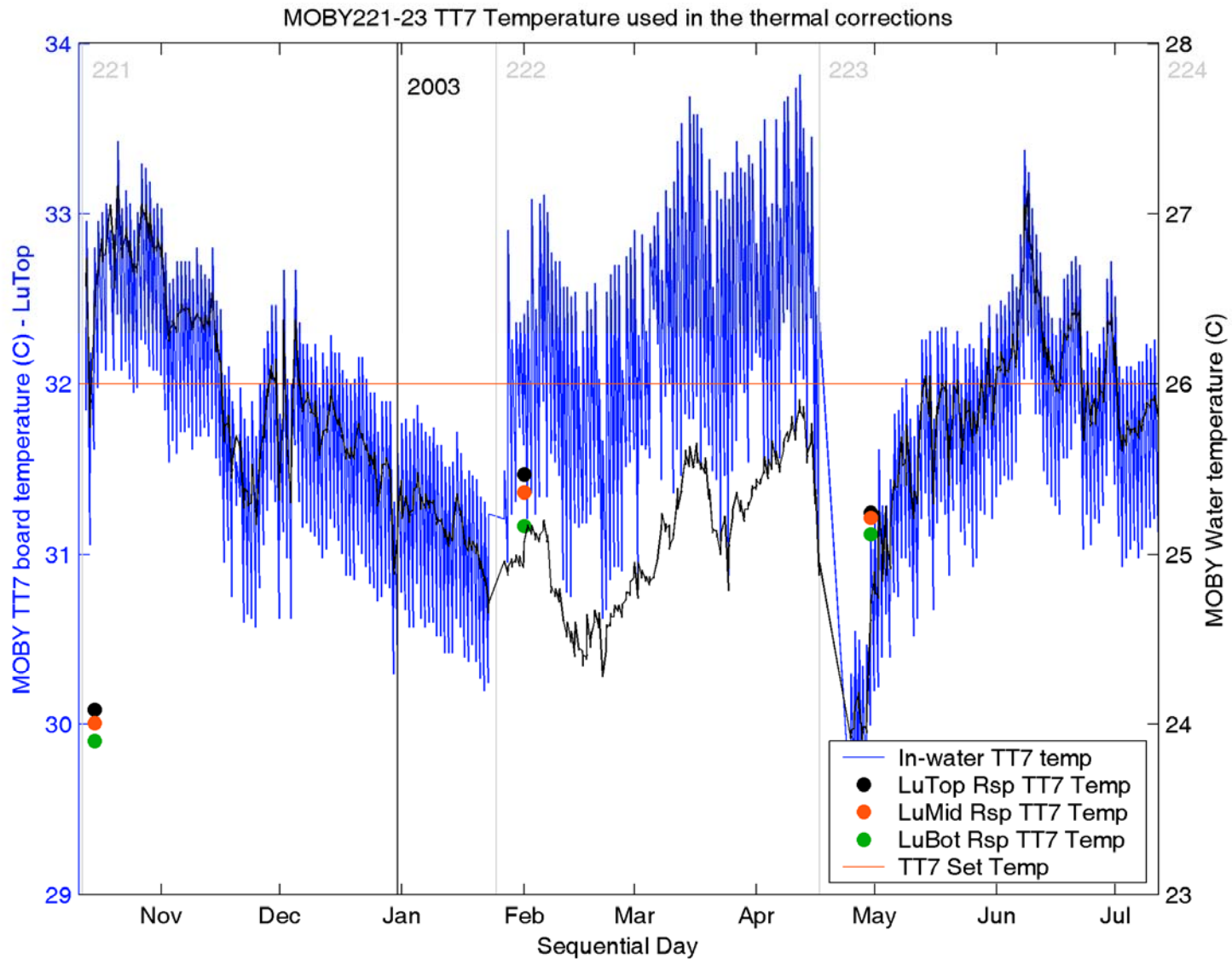
System Responses - The pre and post radiometric and wavelength calibrations are being recomputed with new stray-light and thermal corrections. The average of the pre and post calibrations will be applied as the final response functions.

Quality Control - Changed to Mueller pure water K1's and added a flag for questionable data.

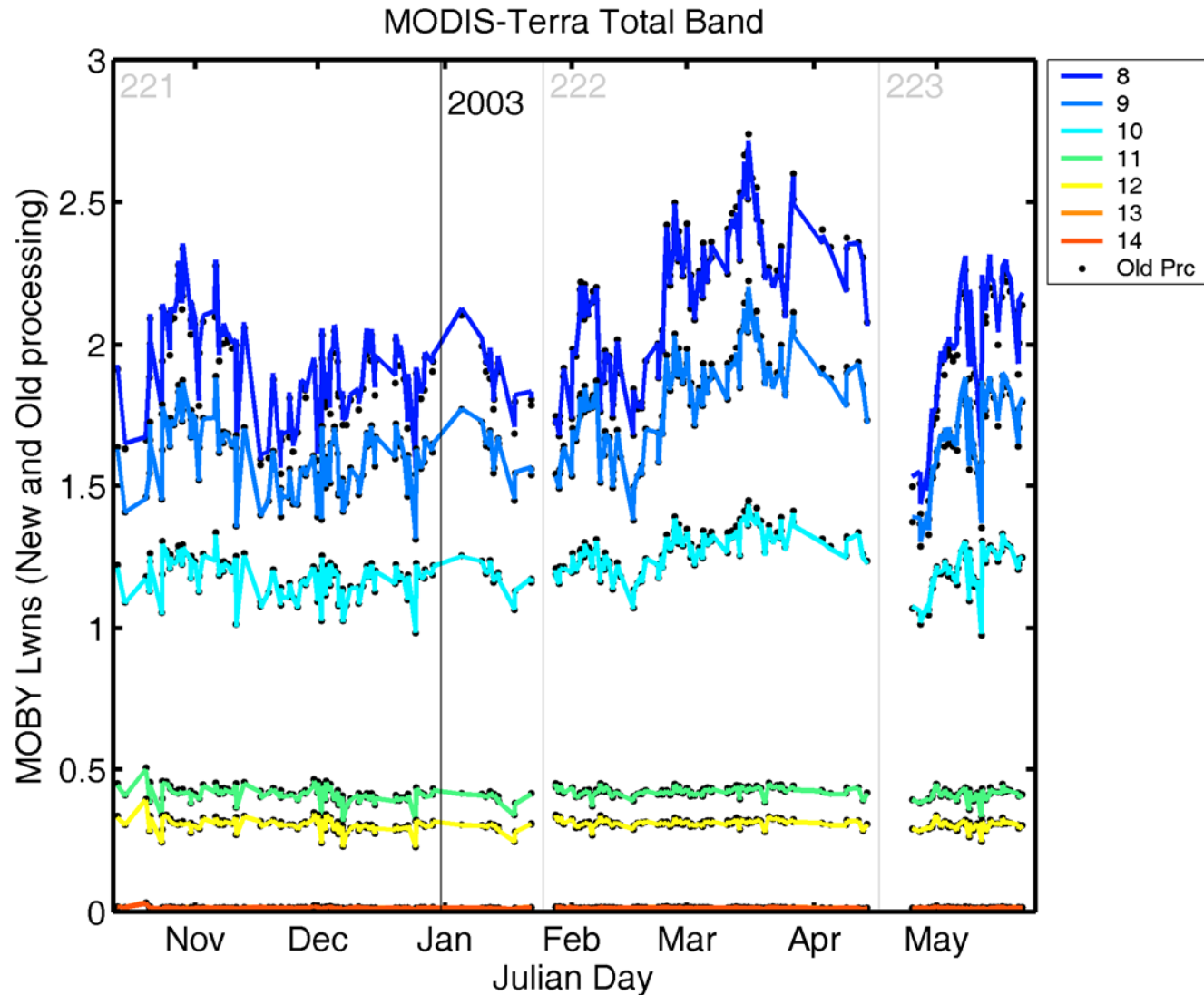
Initial Test Results: MOBY Reprocessing



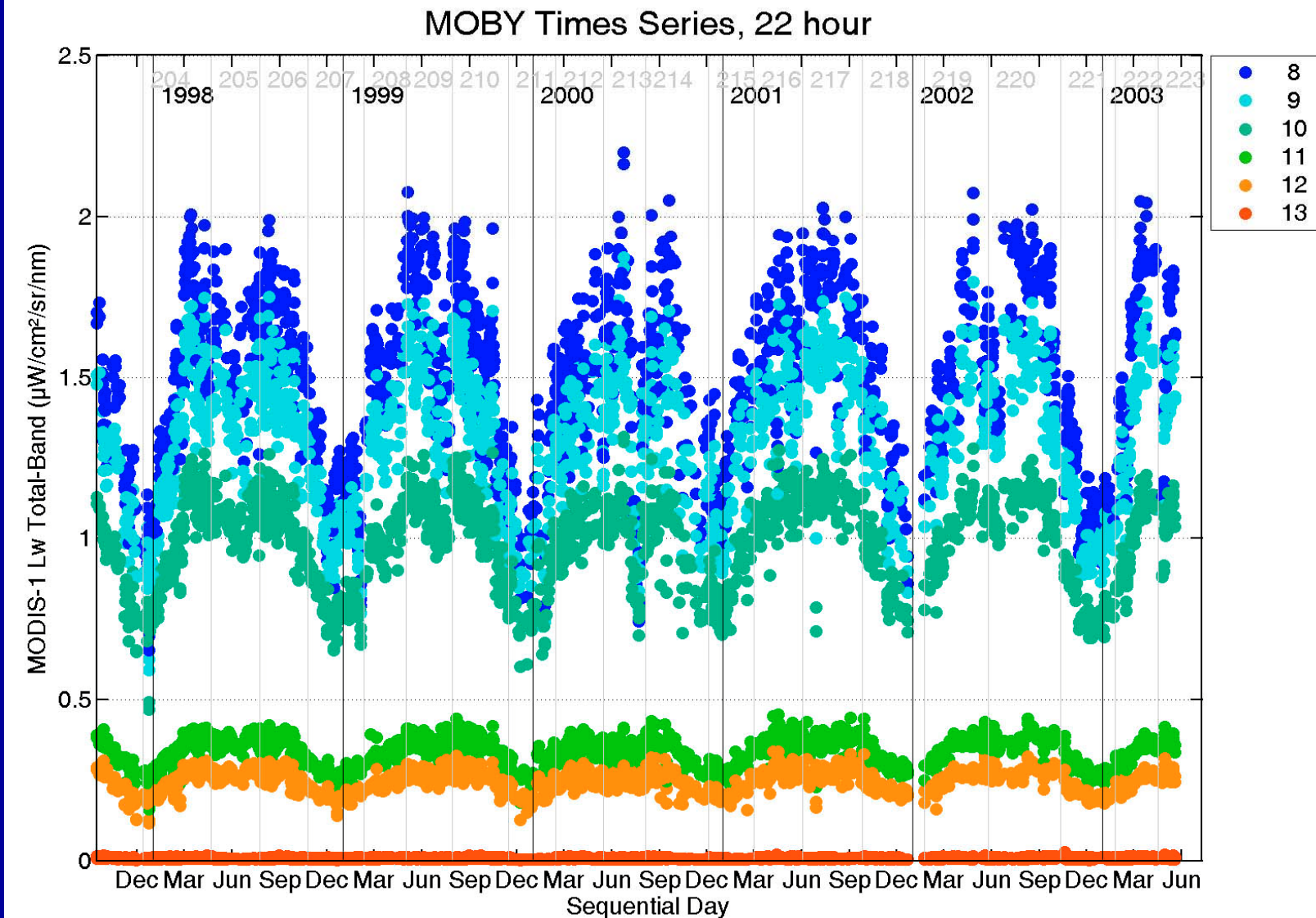
Thermal Corrections



Initial Results: MOBY Reprocessed Lwn



MOBY Lw Time-Series MODIS Terra



Work In Progress - Reprocessing 3 Potential

Apply Mueller Shadowing Model Corrections

Improve NIR Lw Computations

**Improve UV System Responses with Blue LED
Calibration Sources**

**Reduce Calibration System Uncertainty with
NIST SLM's & VXR MOBY Time Series**

MOBY - A Primary Reference Standard for Climate Quality Ocean Color Time-Series

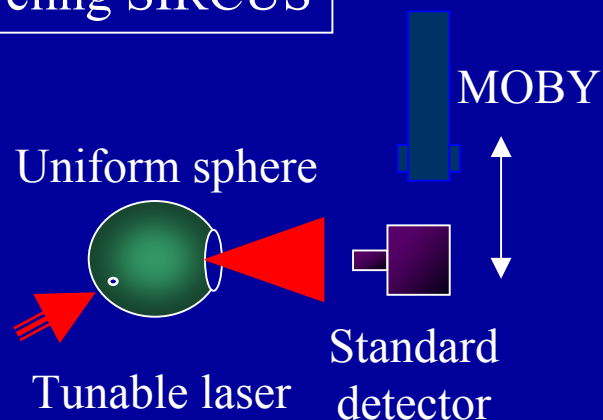
- **Six Year + Time-Series 7/20/97 to Present**
- **NIST Radiometric Scale & Collaboration**
- **Verification of System Performance**
- **Stray Light and Thermal Characterizations**
- **Sensor Spectral Band Matching**
- **Ocean Color Sensors Supported with MOBY Scale:**
 - **Japan - OCTS**
 - **French - POLDER**
 - **US - SeaWiFS**
 - **US - MODIS (Terra and Aqua)**
 - **US - MISR (Terra)**
 - **Europe - MERIS**
 - **Japan- GLI**



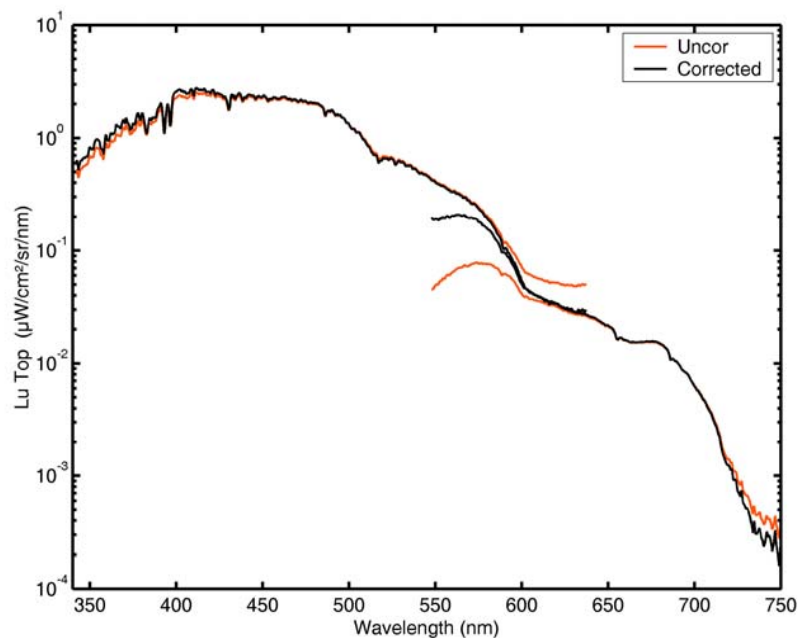
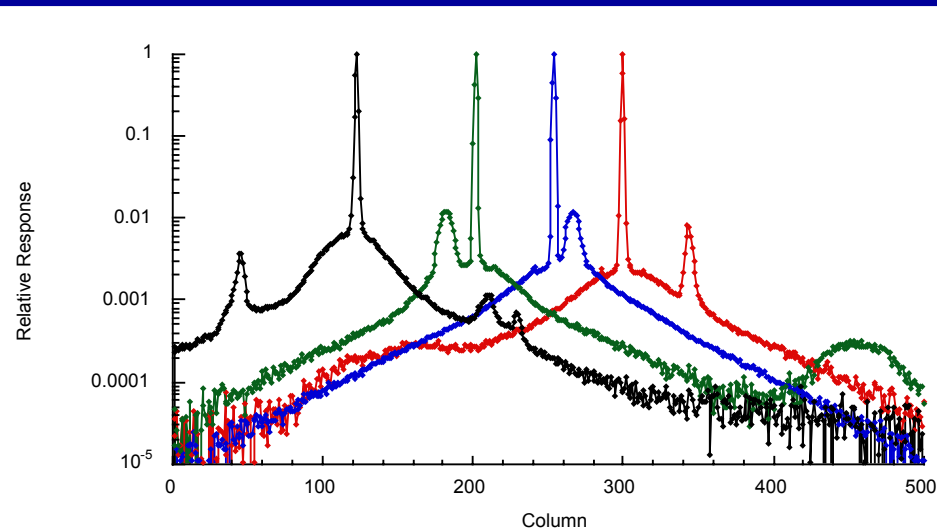
Ancillary slides

Stray Light & MOBY

Traveling SIRCUS

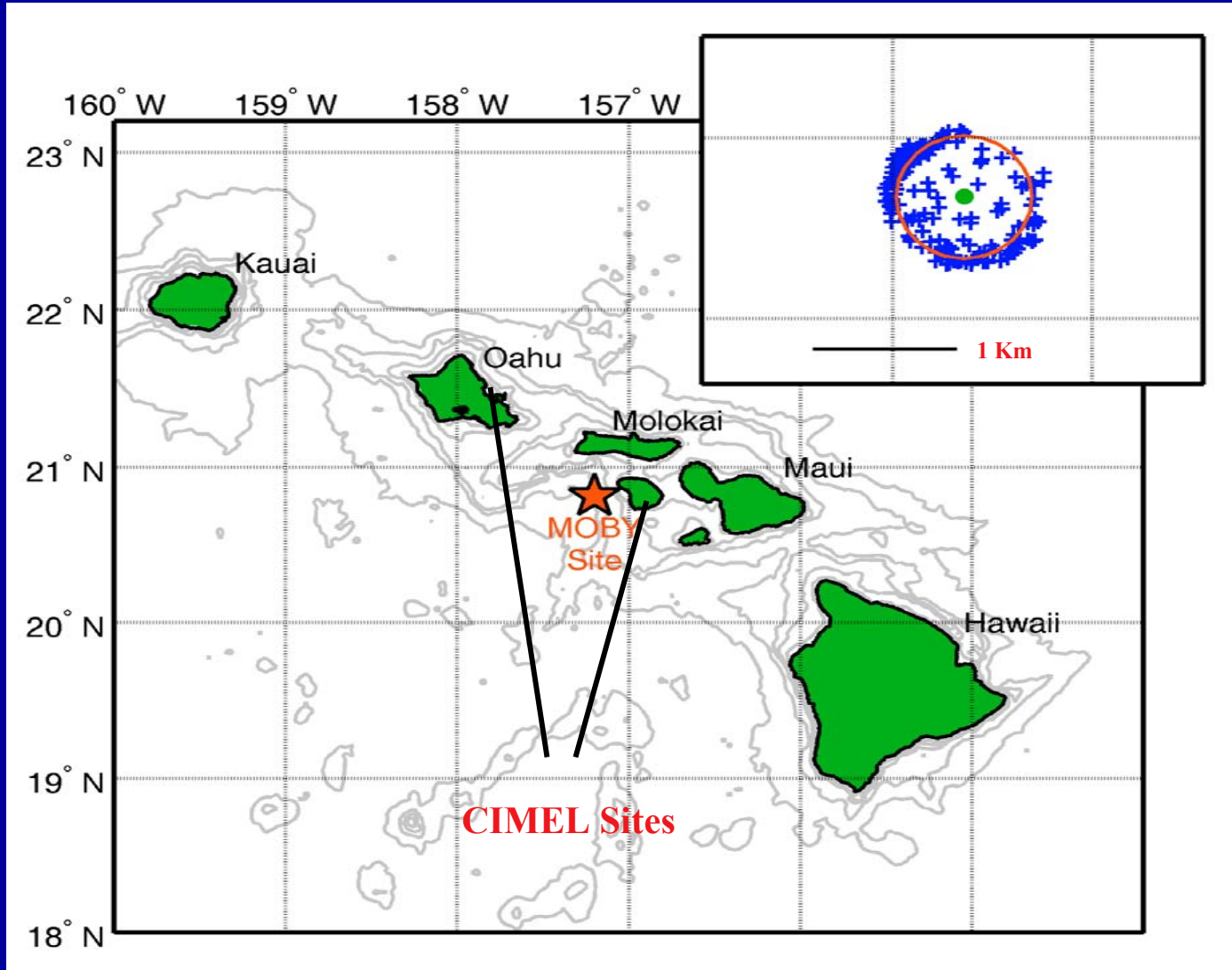


Response found at many wavelengths



Corrected Lu's
-increase in UV
-better agreement in overlap region

Site Location & Watch Circle



mm